WHAT IS CLAIMED IS:

[c01] 1. A two-stage pulse detonation system, comprising:

at least one pre-combustor configured to burn a mixture of a hydrocarbon fuel and a gas;

at least one converging-diverging nozzle coupled to said at least one pre-combustor and configured to allow at least some of said burned mixture to pass through said at least one converging-diverging nozzle; and

at least one geometric resonator coupled to said at least one converging-diverging nozzle and configured to receive said at least some of said burned mixture and detonate at least a portion of said received burned mixture.

[c02] 2. The two-stage pulse detonation system of claim 1, wherein said gas is air.

[c03] 3. The two-stage pulse detonation system of claim 1, wherein said at least one pre-combustor is configured to burn said mixture at a constant pressure.

[c04] 4. The two-stage pulse detonation system of claim 2, wherein said mixture is a rich fuel-air mixture.

[c05] 5. The two-stage pulse detonation system of claim 2, wherein said mixture has a fuel-to-air ratio in the range of about 2 to about 3.

[c06] 6. The two-stage pulse detonation system of claim 1, further comprising at least one resonator exit nozzle coupled to said at least one geometric resonator where said resonator exit nozzle is configured to direct at least some of said detonated burned mixture to an exit of said resonator exit nozzle.

[c07] 7. The two-stage pulse detonation system of claim 1, wherein said at least one converging-diverging nozzle is configured as a continuous annulus along a perimeter of said at least one geometric resonator.

[c08] 8. The two-stage pulse detonation system of claim 1, wherein a plurality of said converging-diverging nozzles are positioned along a perimeter of said at least one geometric resonator, and at least some of said converging-diverging

nozzles are configured to provide said fuel-gas mixture into said at least one geometric resonator.

[c09] 9. The two-stage pulse detonation system of claim 1, wherein said at least one converging-diverging nozzle comprises at least one surface having a plurality of ports configured to inject a second gas into said portion of said burned mixture passing through said converging-diverging nozzle.

[c10] 10. The two-stage pulse detonation system of claim 9, wherein said second gas is air.

[c11] 11. The two-stage pulse detonation system of claim 9, wherein said at least one surface is a converging surface of said at least one converging-diverging nozzle.

[c12] 12. The two-stage pulse detonation system of claim 9, wherein said at least one surface is a diverging surface of said at least one converging-diverging nozzle.

[c13] 13. The two-stage pulse detonation system of claim 9, wherein at least some of said plurality of ports injects said second gas at an angle in the range of about 0° to about 45° with respect to a normal to said surface.

[c14] 14. The two-stage pulse detonation system of claim 9, wherein at least some of said plurality of ports injects said second gas at an angle in the range of about 0 to about 90° with respect to a normal to said surface.

[c15] 15. The two stage pulse detonation system of claim 9, wherein at least some of said ports direct said second gas upstream into said burned mixture passing through said converging-diverging nozzle.

[c16] 16. The two stage pulse detonation system of claim 9, wherein said ports are located equidistant from each other along said surface.

[c17] 17. The two stage pulse detonation system of claim 9, wherein said ports are configured to inject said second gas at a pressure to prevent said burned mixture passing through said at least one converging-diverging nozzle from entering said ports.

[c18] 18. The two stage pulse detonation system of claim 9, wherein a spacing between edges of adjacent ports is equal to a width of said ports.

[c19] 19. The two stage pulse detonation system of claim 9, wherein said second gas is heated prior to being injected into said burned mixture passing through said at least one converging-diverging nozzle.

[c20] 20. The two stage pulse detonation system of claim 10, wherein an amount of said air injected from said ports combines with said burned mixture passing through said converging-diverging nozzle so as to attain a fuel-to-air ratio of about 1.

[c21] 21. The two stage pulse detonation system of claim 1, wherein said geometric resonator has a pressure wave reflection surface.

[c22] 22. The two stage pulse detonation system of claim 21, wherein said pressure wave reflection surface is configured to direct at least some reflected pressure waves to a focal point of said reflection surface.

[c23] 23. The two stage pulse detonation system of claim 21, wherein said pressure wave reflection surface has a wedge shape with an upper surface and a lower surface.

[c24] 24. The two stage pulse detonation system of claim 21, wherein said pressure wave reflection surface has a conical shape.

[c25] 25. The two stage pulse detonation system of claim 21, wherein a shape of said pressure wave reflection surface is chosen from a group comprising cylindrical, spherical, flat, parabolic, and faceted.

[c26] 26. The two stage pulse detonation system of claim 21, wherein said pressure wave reflection surface comprises a plurality of portions, where a shape of at least one of said portions is chosen from the group comprising parabolic, cylindrical, flat, spherical and faceted.

[c27] 27. The two stage pulse detonation system of claim 21, wherein said pressure wave reflection surface begins at a point corresponding to an edge of said at least one converging-diverging nozzle.

[c28] 28. The two stage pulse detonation system of claim 21, wherein said pressure wave reflection surface is configured to reflect at least some pressure waves to a focal point which corresponds to a pressure stagnation region formed by at least some of said received burned mixture exiting said at least one converging-diverging nozzle.

[c29] 29. A two-stage pulse detonation system, comprising:

at least one pre-combustor configured to burn a mixture of a hydrocarbon fuel and a gas;

at least one nozzle coupled to said at least one pre-combustor and configured to allow at least some of said burned mixture to pass through said at least one nozzle; and

at least one geometric resonator coupled to said at least one nozzle and configured to receive said at least some of said burned mixture and detonate at least a portion of said received burned mixture, wherein said geometric resonator has a pressure wave reflection surface having a wedge shape with an upper surface and a lower surface.

[c30] 30. The two stage pulse detonation system of claim 29, wherein an angle between said upper surface and said lower surface is in the range of about 45° to about 120°.

[c31] 31. The two stage pulse detonation system of claim 29, wherein an angle between said upper surface and said lower surface is about 55°.

[c32] 32. The two stage pulse detonation system of claim 29, wherein said at least one nozzle is a converging-diverging nozzle.

[c33] 33. The two stage pulse detonation system of claim 29, wherein said at least one nozzle is configured as a continuous annulus along a perimeter of said at least one geometric resonator.

[c34] 34. The two-stage pulse detonation system of claim 29, wherein said at least one nozzle comprises at least one surface having a plurality of ports

configured to inject a second gas into said portion of said burned mixture passing through said nozzle, and wherein said second gas is air.

[c35] 35. The two-stage pulse detonation system of claim 34, wherein at least some of said plurality of ports injects said second gas at an angle in the range of about 0° to about 45° with respect to a normal to said surface.

[c36] 36. The two-stage pulse detonation system of claim 34, wherein at least some of said plurality of ports injects said second gas at an angle of about 45° with respect to a normal to said surface.

[c37] 37. The two stage pulse detonation system of claim 34, wherein at least some of said ports direct said second gas upstream into said burned mixture passing through said nozzle.

[c38] 38. The two stage pulse detonation system of claim 34, wherein said ports are configured to inject said second gas at a pressure to prevent said burned mixture passing through said at least one nozzle from entering said ports.

[c39] 39. The two stage pulse detonation system of claim 34, wherein said second gas is heated prior to being injected into said burned mixture passing through said at least one nozzle.

[c40] 40. The two stage pulse detonation system of claim 34, wherein an amount of said air injected from said ports combines with said burned mixture passing through said converging-diverging nozzle to attain a fuel-to-air ratio of 1.

[c41] 41. The two stage pulse detonation system of claim 29, wherein said pressure wave reflection surface is configured to direct at least some reflected pressure waves to a focal point of said reflection surface.

[c42] 42. The two stage pulse detonation system of claim 29, wherein said pressure wave reflection surface begins at a point corresponding to an edge of said at least one nozzle.

[c43] 43. The two stage pulse detonation system of claim 29, wherein said pressure wave reflection surface is configured to reflect at least some pressure

waves to a focal point which corresponds to a pressure stagnation region formed by at least some of said received burned mixture exiting said at least one nozzle.

[c44] 44. The two-stage pulse detonation system of claim 29, further comprising at least one resonator exit nozzle coupled to said at least one geometric resonator where said resonator exit nozzle is configured to direct at least some of said detonated burned mixture to an exit of said resonator exit nozzle.

[c45] 45. The two-stage pulse detonation system of claim 29, wherein a plurality of said nozzles are positioned along a perimeter of said at least one geometric resonator, and at least some of said nozzles are configured to provide said at least burned mixture into said at least one geometric resonator.

[c46] 46. A two-stage pulse detonation system, comprising:

at least one pre-combustor configured to burn a mixture of a hydrocarbon fuel and a gas;

at least one nozzle coupled to said at least one pre-combustor and configured to allow at least some of said burned mixture to pass through said at least one nozzle; and

at least one geometric resonator coupled to said at least one nozzle and configured to receive said at least some of said burned mixture and detonate at least a portion of said received burned mixture,

wherein said at least one nozzle comprises at least one surface having a plurality of ports configured to inject a second gas into said portion of said burned mixture passing through said nozzle, and wherein at least some of said plurality of ports injects said second gas at an angle in the range of about 0° to about 45° with respect to a normal to said surface.

[c47] 47. The two-stage pulse detonation system of claim 46, wherein said at least one nozzle is a converging-diverging nozzle.

[c48] 48. The two-stage pulse detonation system of claim 46, wherein said gas is air.

[c49] 49. The two-stage pulse detonation system of claim 46, further comprising at least one resonator exit nozzle coupled to said at least one geometric resonator where said resonator exit nozzle is configured to direct at least some of said detonated burned mixture to an exit of said resonator exit nozzle.

[c50] 50. The two-stage pulse detonation system of claim 46, wherein said at least one nozzle is configured as a continuous annulus along a perimeter of said at least one geometric resonator.

[c51] 51. The two-stage pulse detonation system of claim 46, wherein a plurality of said nozzles are positioned along a perimeter of said at least one geometric resonator, and at least some of said nozzles are configured to provide said at least burned mixture into said at least one geometric resonator.

[c52] 52. The two-stage pulse detonation system of claim 46, wherein said second gas is air.

[c53] 53. The two-stage pulse detonation system of claim 46, wherein said at least one surface is a converging surface of said at least one nozzle.

[c54] 54. The two-stage pulse detonation system of claim 46, wherein said at least one surface is a diverging surface of said at least one nozzle.

[c55] 55. The two-stage pulse detonation system of claim 46, wherein at least some of said plurality of ports injects said second gas at an angle of about 45° with respect to a normal to said surface.

[c56] 56. The two stage pulse detonation system of claim 46, wherein at least some of said ports direct said second gas upstream into said burned mixture passing through said nozzle.

[c57] 57. The two stage pulse detonation system of claim 46, wherein said ports are located equidistant from each other along said surface.

[c58] 58. The two stage pulse detonation system of claim 46, wherein said ports are configured to inject said second gas at a pressure to prevent said burned mixture passing through said at least one nozzle from entering said ports.

[c59] 59. The two stage pulse detonation system of claim 46, wherein a spacing between edges of adjacent ports is equal to a width of said ports.

[c60] 60. The two stage pulse detonation system of claim 46, wherein said second gas is heated prior to being injected into said burned mixture passing through said at least one nozzle.

[c61] 61. The two stage pulse detonation system of claim 46, wherein said geometric resonator has a pressure wave reflection surface.

[c62] 62. The two stage pulse detonation system of claim 61, wherein said pressure wave reflection surface is configured to direct at least some reflected pressure waves to a focal point of said reflection surface.

[c63] 63. The two stage pulse detonation system of claim 61, wherein said pressure wave reflection surface has a wedge shape with an upper surface and a lower surface.

[c64] 64. The two stage pulse detonation system of claim 61, wherein said pressure wave reflection surface has a conical shape.

[c65] 65. The two stage pulse detonation system of claim 61, wherein a shape of said pressure wave reflection surface is chosen from a group comprising cylindrical, spherical, flat, parabolic, and faceted.

[c66] 66. The two stage pulse detonation system of claim 61, wherein said pressure wave reflection surface comprises a plurality portions, where a shape of at least one of said portions is chosen from the group comprising parabolic, cylindrical, flat, spherical and faceted.

[c67] 67. The two stage pulse detonation system of claim 61, wherein said pressure wave reflection surface begins at a point corresponding to an edge of said at least one nozzle.

[c68] 68. The two stage pulse detonation system of claim 61, wherein said pressure wave reflection surface is configured to reflect at least some pressure waves to a focal point which corresponds to a pressure stagnation region formed by at

least some of said received burned mixture exiting said at least one converging-diverging nozzle.

[c69] 69. A two-stage pulse detonation system, comprising:

at least one pre-combustor configured to burn a mixture of a hydrocarbon fuel and a gas;

at least one converging-diverging nozzle coupled to said at least one pre-combustor and configured to allow at least some of said burned mixture to pass through said at least one converging-diverging nozzle; and

at least one geometric resonator coupled to said at least one converging-diverging nozzle and configured to receive said at least some of said burned mixture and detonate at least a portion of said received burned mixture,

wherein said at least one converging-diverging nozzle comprises at least one surface having a plurality of ports configured to inject a second gas into said portion of said burned mixture passing through said converging-diverging nozzle, and wherein at least some of said plurality of ports injects said second gas at an angle in the range of 0° to 45° with respect to a normal to said surface.

[c70] 70. A two-stage pulse detonation system, comprising:

at least one pre-combustor configured to burn a mixture of a hydrocarbon fuel and a gas;

at least one converging-diverging nozzle coupled to said at least one pre-combustor and configured to allow at least some of said burned mixture to pass through said at least one converging-diverging nozzle; and

at least one geometric resonator coupled to said at least one converging-diverging nozzle and configured to receive said at least some of said burned mixture and detonate at least a portion of said received burned mixture, wherein said geometric resonator has a pressure wave reflection surface having a wedge shape with an upper surface and a lower surface,

wherein said at least one converging-diverging nozzle comprises at least one surface having a plurality of ports configured to inject a second gas into said portion of said burned mixture passing through said converging-diverging nozzle, and wherein at least some of said plurality of ports injects said second gas at an angle in the range of 0° to 45° with respect to a normal to said surface.